EXPLANATION OF PLATES.

OLIVE TUBERCULOSIS.

PLATE XIV. Olive branch 18 inches long, bearing 29 tubercles, only part of which are seen in the plate, and none are fully matured. Several of the tubercles have but recently broken through the bark of the branch. This branch was cut July 29, 1890, from a badly infected olive tree growing in an old grove two miles south of Palma, in the province of Naples, Italy. Photograph of fresh material.

PLATE XV. FIG. 1. Well-matured olive tubercles of natural size, showing the usual ruptured condition of the top. The rupturing is preceded by a slight pitting at the surface, as shown in the lower tumor. Material from near Genoa, Italy.

2. Olive tumors from the same source as those of Fig. 1. The lower tumor shows an opening through which some insect has escaped, which inhabits the old tumor, and which may assist in spreading the disease.

3. Section through a tumor. Shows the hypertrophy of the tissue and the degeneration at the central part of the tumor where the bacilli are situated. After Briosi and Cavara.

4. *Bacillus oleæ* (Arcangeli), Trevisan. From figures of stained slide preparations by Briosi and Cavara. I have seen the original preparations given in Figs. 3 and 4.

RECENT INVESTIGATIONS OF SMUT FUNGI AND SMUT DISEASES.

AN ADDRESS DELIVERED BEFORE THE SOCIETY OF AGRICULTURISTS OF BERLIN, FEBRUARY 17, 1888.

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Translated from *Nachrichten aus dem Klub der Landwirthe zu Berlin*, Nos. 220-222, by Erwin F. Smith.

(*Continued from p.* 71.)

For the solution of the first question some important data have been pointed out already in speaking of the mode of infection, to wit, the application of the germs and their penetration into the host. From the results of the first five series of experiments it is evident that the period of receptivity in the seedlings is very transitory. The slower this stage of growth the more probable it is that the germ which has penetrated at the right spot will actually reach the growing point in the given time; and this must be reached if the nascent blossoms and fruits (the subsequent location of the smut beds) are to become smutty. On the contrary, the more rapid this stage of growth the less must be the probability that the germ can reach the growing point in the short time before the seedling begins to elongate. And from this point of view the most extreme case would be when a very greatly hastened development of all seedlings altogether prevented the passage of the penetrated germ into the growing point; in this case, in spite of all penetrated germs, the appearance of the smut diseases would be impossible.

Now, in the first place, the rate of development of seedlings may be very different for different kinds of plants, and in general it may well depend on this whether they are or are not susceptible to smut diseases;* furthermore, in the particular forms which are attacked, it may fluctuate noticeably according as they belong to special races or sorts, and consequently these are more or less receptive. But more than all this, in particular individuals of the same species of cultivated plant a somewhat hastened or retarded development during germination will assert itself in smaller fluctuations, which here nevertheless may be decisive. For this reason it seems only natural that the receptivity toward smut fungi will be individually different, that consequently in the same material, under otherwise similar conditions, only a portion of the host plants will become smutty, as was actually the case in our experiments. The fungous germs certainly penetrated into every seedling, but the growing point was not reached in all cases, and only those finally became smutty in which it was reached. To what extent the temperature may influence the result I will only point out briefly. Warmth hastens development, but whether it acts equally on the growth of the seedlings and on the fungous germs in them had to be decided by infection experiments conducted at higher temperatures than those here described. These supplementary experiments showed that when seedlings, as in I, were infected at 15 degrees C. only 3 per cent of the plants became smutty, while at still higher temperatures only 1 to 2 per cent appeared or no smutty plants whatever. † The higher temperature, therefore, hastens the growth of the seedling proportionately more than that of the fungous germ, and thus hinders the development of smut in the plants.

It now remains to ascertain the reasons why, in all the series of experiments, not a single one of the infected barley seedlings produced a smutty plant. In the first place, it is self-evident that the negative results with the barley can not change in the least the positive results with the oats. On the other hand, without further inquiry, the explanations given for the incomplete sickening of the oat plants are by no means to be urged

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* From the sum of the experiments and the preceding observations it follows naturally *that the simple penetration of the germ into the host plants,* on which the school of De Bary laid such stress, is not decisive for the appearance of smut diseases. But beyond this, I have by special experiments determined *that the most diverse smut germs can penetrate into all sorts of plants, which are never attacked by smuts,* consequently, the penetration of the germs only proves an unimportant detail. The results of these many experiments establish the accuracy of the views and conjectures on parasitism and the way it may occur in nature, of which I have already spoken in *Den Brandpilzen* I, p. 26–29.

† In the paniculate heads of the oat, sound spikelets sometimes occur at the tip of a panicle while the lower spikelets are destroyed by smut. In such cases the penetrated smut germs had not reached the uppermost point of the inflorescence when the elongation began; therefore these remained sound while the lower were attacked by smut. The correctness of this interpretation of the interesting discovery is shown by the fact that in such partially diseased panicles the *uppermost portions without exception are sound and the lower are diseased,* but never do the upper become diseased while the lower remain sound.

for the entire immunity from smut observed in the infection experiments with barley, and especially because barley in the field is more frequently attacked by the dusty smut than oats. The results remained a complete enigma for three long years. But then this case also was explained as naturally as imaginable.

I received accidentally from Yokohama, through Chief Brigade Physician, Dr. Kügler, some smutty spikes of barley. It occurred to me that it was worth while to see whether the dusty smut on the barley in Japan agreed exactly with the dusty smut in Germany. I therefore sowed its spores, which in shape and size were indistinguishable from our own dusty smut, in nutrient solutions. Here it came to pass that in the universal germination of the smut spores into a promycelium *no conidia* were produced upon the latter, although they appear in countless numbers, as we know, in the spore germination of our own dusty smut. The promycelium afterwards branched in the same way, and just as abundantly, as any mold, but in a purely vegetative manner, without any formation of conidia.

In this manner mycelial masses were produced of such dimensions as can scarcely be derived from Saprophytes upon slides. As soon as the nutrient solutions were exhausted the remotest threads grew out stolonlike, and spread to a great distance, just as I have described and figured it for several fungi in my cited book. *The smut on the barley in Yokohama is therefore a fungus distinct from our dusty smut.* Unfortunately it was spring, and I had for comparison no smutty barley grown in our own fields. But in the following summer, as soon as the smut showed itself in the barley fields, I made cultures from its spores and found that they germinated just like those from Japan. I repeated the experiment with barley smut taken from as many places as possible in the vicinity of Münster in Wesen, but the spores always germinated without conidia. I communicated this observation to my distinguished friend and patron, Prof. Julius Kühn, of Halle, and requested from him some spikes of wheat containing fresh smut. In these also was the same fungus as in the barley, the spores produced no conidia. *According to this the smut fungus on barley and wheat is not the same as that on oats.* In spite of the similar spore form a great difference between the two is shown in the germination of the spores in nutrient solutions.

The negative results of barley infections, and the endeavor to give a natural explanation, led to a further positive result, the discovery of a new form of smut, which, in spite of its universal distribution, had remained unknown, and for the recognition of which it was first necessary to find out, by means of the artificial culture of smut fungi, a new method of diagnosis. I call the new fungus, which occurs on the Hordeæ, *Ustilago hordei.* The consonant behavior of the fungus from Japan and from Germany is evidence at once of its specific peculiarity and its value as a member of the genus *Ustilago.**

*A varying behavior during spore germination in water, sometimes with and again without conidia, was known long ago for the dusty smut, but owing to the rudimentary germination of the spores in water was not followed further. Moreover, seven years

B. For the infection experiments with millet smut, *Ustilago cruenta*, I selected the largest kind of millet, viz, *Sorghum saccharatum* (*nigrum*), because in the others the seedlings are entirely too small and therefore not suited for the experiments. Even the seedlings of the sugar millet are quite small in comparison with those of our own cereals. They have, on the other hand, the advantage that at first they grow much more slowly than the seedlings of oats and barley.

The millet smut (*Hirsebrand*), like the dusty smut, appears in the fruiting spikelets, and the grains are changed into a black mass of smut.* The spores germinate readily and produce sprout conidia in endless abundance. These are deposited in the nutrient solution as a precipitate, which differs strikingly from that of the dusty smut in its whiter color and the non-gelatinizing membrane of the conidia.

I. The first series of experiments, in 1885, was reduced to 32 plants by a hail storm. The germinating embryos were infected with the sprout conidia of *U. cruenta* by means of the atomizer. Among the 32 plants which remained there were, in autumn, 12 smutty and 20 sound.

II. The next series of experiments was made in the following year by direct infection of seedlings, which, however, were not all of the same size or in quite the same stage of germination. In autumn the harvest of 270 plants yielded 120 sound and 150 smutty.

Early experiments, with sufficient materials, where the seedlings were rigorously sorted according to their size, were not begun till 1887.

III. First, the smallest plants, in which the growing point was just emerging from the grain, were picked out and infected. Here, in autumn, out of 250 plants were harvested 180 smutty and 70 sound.†

IV. Next, seedlings were selected with shoots a centimetre long. Here, in autumn, from 150 infected plants were gathered only 24 smutty and 126 sound.

V. Seedlings with shoots 1½ centimetres long. Here, in autumn, from 190 infected plants, 12 diseased panicles were counted; 178 remained sound.

VI. Seedlings with shoots 2 centimetres long and projecting from the sheath. In autumn, out of 220 plants only 4 were diseased, the rest were sound.

VII. Seedlings with shoots which had grown through the sheath to a distance of 1 centimetre. Here, in autumn, *no smutty plants* appeared.

VIII. As soon as the millet seedlings were large enough to be infected by spraying the germs into the heart from above, 192 plants,

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ago, in my first culture experiments with the dusty smut, I discovered that the smut spores from barley would not germinate even after one year, while those from oats still germinated readily after more than six years.

* In more than three hundred smutted millet plants, for which I have to thank Prof. Julius Kühn, I found the smut nowhere except in the ovaries.

† There can be no doubt that the larger per cent of smutty plants in the millet as compared with oats, is referable to the slower growth of the millet seedlings. Otherwise, on account of their smallness, the seedlings are less favorable objects for infection than those of oats.

which had reached a size of about 5 to 6 inches, were thus infected. Where the germs touched, a local sickening was visible after 4 to 6 days. This took the form of a yellowing and subsequent shriveling of the leaves. These were covered with penetration spots, and penetrated in all parts by richly branched fungous threads. The leaves died, but neither completely nor with the formation of smut in their interior. As soon as the plants were compensated by new sound leaves from the bud, they appeared healthy again; but were, of course, somewhat delayed in their development in proportion to the disturbance. Moreover, this whole series of plants proved sound, and brought forth healthy panicles.

IX. An additional 210 millet plants, about a a foot high, were infected in the heart from above. Here the effect was still more remarkable. The young leaves which had been touched and attacked, shriveled considerably after a week, the heart of the plant became very pale, and the mycelium grew luxuriantly through all the attacked leaves. Nevertheless, even here, the diseased leaves were subsequently replaced by sound ones, and aside from the delay in development the plants suffered no injury. The subsequent harvest yielded only sound panicles.

X. Again, 120 plants, 1½ to 2 feet high, were infected in the same way. The symptoms on the attacked leaves grew worse in proportion to the increased size of the vegetative point, so that from external appearances it seemed as if the plants would perish; but this did not happen, and again the new leaves were sound. The result in autumn was the same as before, only sound plants.

The panicle can not be reached by infection from above in millet any more than in oats. It is securely inclosed by the leaves of the bud, and subsequently pushes out sidewise from these. For this reason, additional infections, when the plants were 3 to 4 feet high, had a purely negative result. The young leaves were luxuriantly traversed by the penetrated germs, but the panicles remained uninjured.

The final result of the experiments with millet smut on the sugar millet [sorghum] points to the following conclusions: The plants can be infected with the smut germs in all young undeveloped parts; but only those smut germs which have penetrated into the *nascent* shoot, and have thus reached the growing point, actually produce smut in the panicles, which is its exclusive location. These fungous germs, which have penetrated the host plant in the first stage of germination, remain, as in oats, latent in the plants till their sexual maturity, and then only do they come to maturity in the young ovaries, and to the production of smut beds, which is equivalent to the destruction of the ovaries or of the panicle.

It is worthy of remark that we can not discover the least sign of disease in the plants which bear the destructive germ concealed in their growing points; that, on the contrary, they appear even more luxuriant than the others; and furthermore, that the smutty panicles appear much sooner than the sound ones. For example, in the third series of experiments. 102 smutty panicles had developed up to September 3,

but yet no sound ones. I fully believed that all of the plants would be smutty, until on September 10, the first sound panicle appeared. On October 1 were counted 30 sound panicles and 140 smutty ones; and finally, on October 15, the proportion was 180 diseased, smutty plants to 70 sound ones. In plants which conceal the germ of destruction we find slight traces of the fungous threads only in the nodes and in the growing points, and in the latter they do not attain further development until the ovaries are formed. They then proceed to the formation of spores in this place only, not in the leaves, where they remain sterile and do not produce a single smut spore. The ovaries swell mightily with the rapid and abundant development of the fungus in them, and finally, like the horns of ergot, grow to be many times their natural size, projecting far out of the panicles. Finally, after the complete spore formation of the fungus, they break up and allow the spores to dust away. In this stage scarcely a trace of the mycelium of the fungus is to be found in the host plant.

The behavior of corn smut is directly opposed to that of the smut forms which inhabit the grain exclusively. This form can produce its smut beds on any part of the host plant, and in the strange and repulsive similitude of cancriform swellings and ulcers.

For infection experiments with smut germs the big corn plant is an ideal object. All parts of the maize, from the seedling to the inflorescences and fruit-spikes, are developed on a large scale, and are easily accessible for each form of the experiment. The corn smut itself, *Ustilago maydis*, is also a smut form especially suitable for the infection.

C. I began infection experiments with corn smut in the spring of 1885. The spores of *Ustilago maydis* do not germinate in water, or do so very sparsely only after some years. In nutrient solutions they germinate without exception and immediately. They are therefore consigned to nutrient solutions or nutrient substrata, and not to mere water, for full germination. They produce an endless quantity of sprout conidia, and still more rapidly than the two forms of Ustilago previously mentioned, *U. carbo* and *U. cruenta.* The conidia are thrown down as a white, granulous precipitate, which appears even whiter than the sediment of *Ustilago cruenta.* But in this case the sprouting of the conidia takes place *upon* the nutrient solution, where mold-like pellicles are formed, from which the conidia can easily dust off through the air.*

I. In the first series of experiments, in 1885, I infected only young seedlings in different stages of germination. In more than ten distinct sets of experiments the seedlings were copiously sprayed with conidia and were afterwards set out in the field.

After 16 days, very scattering signs of smut were visible among the plants which had been infected in the earliest stage of germination. Below, upon the axes, a smut swelling was developed, in consequence

* This formation of sprout conidia in the air is likewise peculiar to a number of other *Ustilagineæ e. g., Ustilago bromivora* and *Ustilago destruens,* also *Tolyposporium junci,* etc.

of which the plants died. The loss, however, was trifling, amounting to only 4 or 5 per cent. The seedlings which were infected in later stages gave only 1 or 2 per cent of loss. The last set, with open sheath, remained sound.

The few plants which became diseased so early, and which died completely, suggested in their appearance the smutted maize seedlings which Kühn observed and described. The time of the appearance of the smut swellings after the infection also agreed with Kühn's statement.

I now waited, expecting that, as had happened with oat and millet smut, the corn smut would appear upon the fully developed plant, especially in the fertile spikes, but I waited in vain. Already, the fact that, from this time on, the strongly developing axes remained entirely sound had made me suspicious, and when autumn came, and the ears were formed, *not one out of many hundred plants was smutty.*

Before the issue of this experiment, which had consumed several months, I stood at first helpless. The infections were made as carefully as possible, and the failure was not to be explained by these. This must have other causes. All reflections in the course of the winter led me back to this conclusion, *that probably in maize the infection of young seedlings could not lead to the production of smut in the full-grown plant*, as is the case in smut forms living in the grain. At the time of this first series of experiments, in the year 1885, I still held to the old view, universally current until now, that smut germs generally could penetrate only into the young seedlings in order to appear later as smut beds in the full-grown plant, and that, consequently, a penetration of the germ into the plant when it had passed the seedling stage was not possible. I had not then tried infections in the heart of full-grown plants. In the failure of the infections with the corn seedlings I first found the suggestion for the latter. Gradually I came to the conviction that the view that the fungous germ could penetrate only into the seedling was an embarrassing one; that the seedling consisted only of the young parts of plants, and that, of course, the penetration must occur not exclusively in the seedling but also in all places which were in a young condition similar to the seedling. This applied, first of all, to the growing points, the buds, the heart of the plant which was still growing and forming new tissues overhead. Here, therefore, the infections must be made. These I now prepared for by sowing kernels of corn in long beds, in the open air, at the end of April of the following year (1886).

II. In the first half of June, 1886, the maize plants of a long bed were abundantly infected in the heart by means of a suitable spraying flask. For the most part these plants were about a foot high, and the young leaves of the growing point had formed cornets very suitable for receiving the infection. The plants remained uncovered, as a period of dry weather had set in. The injected fluid containing the sprout germs, which at first covered the growing point, was not to be seen on the following days. The leaves of the tip continued to develop during the

next 10 days normally and luxuriantly. On the twelfth there appeared an etiolation in the heart of the plant, which extended upward as far a the leaves had previously been touched by the injected fluid. In the blanching leaves, the surface of which was strewn with penetration spots, there was an abundant production of mycelium, which had penetrated in all directions. In addition, the commencing hypertrophy of tissue was already clearly visible in the attacked and ever-paler appearing parts. After an additional week, in which the growth of the whole plant, including the parts attacked, had proceeded considerably, the cancroid swellings of the smut pustules reached full development and a size never before seen. The entire leaves were covered with a complete crust of pustule, which in part made them almost unrecognizable; out of all parts of the axis, in fantastic forms like ulcers, the great smut swellings grew luxuriantly, so that the plants in their entirety were deformed and spoiled—a complete picture of disease. Scarcely had the rapidly developed swellings reached full size when they lost their white appearance through internal change of color. The spore formation quickly included the whole densely interwoven mycelial skein inside of the swelling, and the final result was a black mass of smut spores inclosed by the external tissue layers of the host plant, *e. g.*, of the pustule.*

Of all the plants which were infected, *i. e.*, more than a hundred, none remained sound after 4 weeks. The smaller they were at the time of infection, the more they suffered. The extension of the young axis, which was disturbed by the formation of smut and the accompanying hypertrophy of tissue, was afterward completed. Whole plants were wasted and distorted by the fungus into miserable objects. They lay in part upon the earth and perished without exception. On the larger plants the formation of pustules was localized upon the upper parts, the only ones attacked. The lower sound leaves continued to nourish the plants and they did not die. In only twelve of these plants did the injected fluid reach as far as, or penetrate into, the nascent staminate inflorescence. To the extent that this happened the parts soon became smutty, sometimes the tips only, and again the lower portions. The glumes and the filaments swelled more than fifty-fold, and in isolated cases became tumors which, by their weight, afterwards bent down the whole panicle. The long series of charts which I have hung up, and which were drawn by my young friend and associate, Dr. Istvanffi, of Klausenburg, will serve to illustrate the most striking cases from these series of experiments.† In the upper part of one of the pictures, in the

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* Through this pathological picture of the cancerous tumors on the maize plant we arrive involuntarily at the notion of what the symptoms would be if the smut spores were not black, and were not produced in such masses as happen in the maize, and if the substratum were not a vegetable, but an animal organism.

† These charts, and many others illustrating the life history of smuts, may be found in Dr. Brefeld's *Heften* V and X, to which he desires me to call attention. These are published by Arthur Felix, Leipsic, Germany. Part X, giving *in extenso* the results here summarized, is now passing through the press.—Tr.

attacked staminate inflorescence, there are a number of fertile blossoms the individual ovaries of which reached the size of a walnut, and were still crowned with the base of the style.

On such plants as survived, the appearances of disease diminished after 6 weeks, with the ripening of spores in the pustules, and not long after only the dried pustules remained; aside from these, and the persistent distortions of the upper part of the axis, nothing more was to be seen of the smut. During this time the fertile inflorescences appeared below on the axis, in the axils of the leaves which had remained sound. No smut was to be seen on these, and later they were pollenized from the staminate inflorescences which had remained sound and developed normally. In autumn, a large number of ears bearing sound, ripe kernels were harvested from these plants.

After this conclusion of the series of experiments no doubt could remain that the smut germs develop, and within 14 days, too, in the particular spots of the young parts of the plants into which they have penetrated, and in these only. All parts of the plants which are not touched directly by the germs remain sound, so that sound ears can be gathered in autumn from maize plants which are infected in the heart in summer and which become smutty on all parts that have been touched directly.

But here was still necessary the additional experiment of verification by which it must actually be proved that the fertile inflorescences also become smutty as soon as they come into direct contact with smut germs while still in a very young condition.

III. Again, the next year I had whole beds of maize plants prepared in the field for supplemental infections. I waited for the time when the pistillate inflorescences should begin to appear on the sound plants. These showed distinctly at the end of July, on the third to fifth internodes of the axis, by a swelling of the leaf sheath. As soon as the swelling had reached the point where the otherwise firmly encompassing ligule was pushed up somewhat from the axis, the infection was made by spraying into the leaf sheath so that the injected fluid containing the sprout germs stood even with the rim of the ligule. More than one hundred plants, each of which, as a rule, afterward brought forth two ears, were infected in this way.

The results of the infection were visible at the expiration of 14 days. The leaf sheaths were burst open, and the ears within came to view as a continuous smut pustule. Individual ears swelled to the size of a child's head, and only here and there distinguishable were the peculiarities of the fertile inflorescence, the ovaries of the young ear; otherwise, for the most part, was to be seen a single deformed, repulsive structure. No fertile inflorescence, which was infected when a young bud, remained uninjured. The narrowly local action of the infection could be shown directly on the plants on which the lowest flower buds were infected but not the upper. The latter always remained sound; the former alone were destroyed.

IV. The formation of the pustules in the very young ear did not yet exactly correspond to the appearances which I had formerly seen on fertile spikes, where each ovary had swollen individually into a tumor as big as a nut, so I extended the experiments still further. Ears which already bore silks were somewhat opened at the tip, and only the exposed ovaries of the spike were infected by means of the sprayer, while the lower were not infected. If the presumption as to the narrowly local action of the infection were correct, then in this case also only the upper ovaries would become smutty.

The ovaries behaved with military punctuality. After 16 days the upper ones swelled, and became almost egg-sized smut tumors, as the suspended pictures show. All of the ovaries lower down on the same spike yielded sound, normal grains.

V. There remained only the incipient adventive roots on the lower nodes of the axis as susceptible objects of attack. The beginnings first appear when the growing points and the leaves have reached full size, *i. e.*, when the plants begin to elongate. They appear in a r.ng around the nodes near the ground; the farther up they are the shorter they remain, and then, generally, they do not penetrate into the earth.

As soon as the tips of the roots were exposed, the infections were made by spraying with the atomizer, and then a shelter from rain was placed over the roots. Once more, after 3 weeks, individual root tips showed swellings of the bigness of a nut on their ends, which meanwhile had elongated. These swellings developed into normal smut pustules, as shown in this sketch.

VI. To round out the experiments, the silks which hung far out of the fertile inflorescences were also infected by spraying. Here the infection had no result, as was to be expected. The silks remained unchanged, and their spikes, which were protected from the infection, also remained entirely sound. The silks, indeed, are no longer young tissue. The fungous germs still penetrate occasionally, but do not develop, because the luxuriant growth of tissues necessary for the formation of pustules is excluded.

VII. All infection experiments made by spraying into the heart of the plant when the sterile inflorescences were already visible in the growing points, were also without results. Penetration spots were still to be found, and also fungous threads in the superficial tissues. Externally on the leaves a slight shrinking was also observed on isolated spots, but they recovered because the fungous germs found in the already too old tissues no suitable place for the production of smut beds. I have already referred to the fact that penetration itself is impossible in still older parts of the maize plant which have reached nearly full growth.

According to this, the final result of all the infections with corn smut on maize is entirely different from the previously described results with smut fungi living exclusively in the grains. The smut germs come to

full development and produce smut pustules and spore beds on every spot of the still undeveloped parts of the plant into which they have penetrated. The action of the germ is narrowly localized—only those parts of the young plant become smutty which have been attacked directly by the fungous germs; all the rest remain normal and sound. The formation of the smut pustules begins quickly, at longest, 3 weeks after the infection.

The complete result of all the here-cited infection experiments with dusty smut, millet smut, and corn smut affords, in the first place, indisputable proof that the germs of smut fungi which live saprophytically outside of the host plants can produce smut diseases.

When the smut was nourished saprophytically longer than a year in continual reproduction outside of the host plant, then only did the outgrowth of the conidia into germ tubes cease. Along with this the power of infection was extinguished, *i. e.*, with the disappearance of a comprehensible morphological character, for the germs can only penetrate into the host plants by means of their germ tubes.

The earlier view that only young seedlings of the host plants are receptive to the fungous germ has not been sustained. On the contrary, the fungous germs can penetrate into all sufficiently young parts of the host plant.

In the grain-infesting smut fungi, *e. g.*, in the dusty smut and millet smut, of all the fungous germs which have penetrated into the young parts of the plant, of course, only those come to maturity, *i. e.*, to the production of smut diseases, which reach the growing point and the place of the here-included nascent inflorescence. This takes place only in the germs which have penetrated into the young seedling in the vicinity of the root nodes during the first stage of germination. For all the other germs which have penetrated later this is already impossible. The vegetative tips with their incipient blossoms, the later place of development of the smut, have already grown away from these, and consequently are entirely out of reach inside of the plant.

The relative rapidity of germination in plants receptive to smut diseases aids materially in determining the subsequent appearance of the smut, *i. e.*, the development of the germ which has penetrated. This may vary according to the accidental temperature prevailing at the time of germination, therefore according to external influences; but from internal causes it will also be dissimilar in particular individuals, which accordingly may show an individually different receptivity.

In the peculiarities formerly stated, and now clearly established by me, the natural explanation is given, so far as regards smut diseases, to the terms "periodic receptivity," "subsequent immunity," and "individual predisposition to an infective disease."

Especially noteworthy is the long incubation period from the penetration of the fungous germ to the outbreak of the disease. The germ of the destructive disease is taken up in the earliest youth of the plant

and first comes to destructive action when the latter is sexually mature. Here we have a case of "definite periodicity in an infectious disease" explained clearly and naturally by actual peculiarities. The disease germs remain latent, and traces even are scarcely to be found. The attacked individuals are even stimulated in their growth, and are in advance of the sound ones—until suddenly at the time of sexual maturity the disease germs, hitherto concealed within, come into destructive operation.

In smut fungi, which do not live exclusively in the grains, but also appear and form smut beds in other parts of the plants, *e. g.*, in corn smut, the infection remains local. The fungous germs proceed to the development of smut in the sufficiently young parts of the plants only on those spots into which they have penetrated. The plants are receptive to the infection as long as young parts are being produced on them. Only when this is no longer the case, *i. e.*, when the plants are full grown, does the stage of immunity begin. To what extent the peculiarities in the smut fungi and smut diseases, which are now explained, may be of value for judgment upon similar occurrences in infectious diseases, especially in pathology, is self-evident.

In conclusion, I may be permitted to observe that seven years' labor was necessary to reach the conclusions on smut fungi and smut diseases given in my first address four years ago, and in this present one. The substance of this address is here made public for the first time as original work.

RIPE ROT OF GRAPES AND APPLES.*

By E. A. Southworth.

Plate XVI.

HISTORY OF THE FUNGUS.

Judging from the bibliography of the fungus of ripe rot and from the very scant specimens in the herbarium, it seems to have received four or five distinct names at the hands of three or more investigators. The fact that it varies greatly in its microscopic and external characters probably accounts for the vicissitudes of nomenclature through which it has passed, and for the fact that one authority has given it two and perhaps three names.

In 1854, M. J. Berkeley described and figured in the Gardeners' Chronicle a disease of the grape caused by a fungus to which he gave the name *Septoria rufo-maculans.* He describes the fungus as attacking ripe fruit and causing considerable destruction. From his figures and general description there is little doubt that the fungus is the same as

* *Glœosporium fructigenum,* Berk.